

SHAPING-LATHE HEADRIG

Now Commercially Available

By PETER KOCH

On September 12, 1975, twenty-five sawmillers from throughout North America watched as a new headrig produced cants of various shapes and a usable residue of flakes from logs of irregular contour. The demonstration at the Stetson-Ross plant in Seattle, Washington, was the unveiling of the commercial model of a design introduced by the Southern Forest Experiment Station 10 years ago.

The new headrig offers four main advantages over traditional chipping headrigs (3). It cuts in the 0-90 mode rather than in the 90-0 or 90-90 mode (Figure 1) and therefore produces a smoother machined surface than other headrigs. Operating on the principle of a shaping-lathe, it relies for work-piece position on end-chucks rather than on through-feed chains or rolls; thus, it can accept short logs with butt-swell, crook, or sweep while other headrigs cannot. Unlike other headrigs, this version can produce rounds, hexagons, octagons, or trapezoids as well

as rectangular cants because cant shape is determined by replaceable cams. Moreover, its residue is veneer-like particles well adapted for use in structural flakeboard.

At the Seattle demonstration, the headrig cut white oak (*Quercus alba* L.), hickory (*Carya* sp.), Southern Red Oak (*Quercus falcata* Michx.), red alder (*Alnus rubra* Bong.), sweet-gum (*Liquidambar styraciflua* L.), and Southern pine (e.g., *Pinus taeda* L.). The machine worked equally well on hardwoods and softwoods.

This commercial model can handle logs 40 to 53 inches long and 4 to 12 inches in diameter (Figure 2). Bolts are clamped in the chucks of the work-piece spindle, which turns at about 15 rpm. Attached to the spindle is a replaceable cam having the shape and dimensions of the desired cant. The cam rotates and moves with the work-piece until it strikes a follower aligned with the cutter-head. As the work-piece makes a single revolution, the center distance between cutter-head and work-piece

changes in response to the cam, and the work-piece (log) is machined to the shape and dimensions of the cam. Since the log makes only a single revolution while being sized, ma-

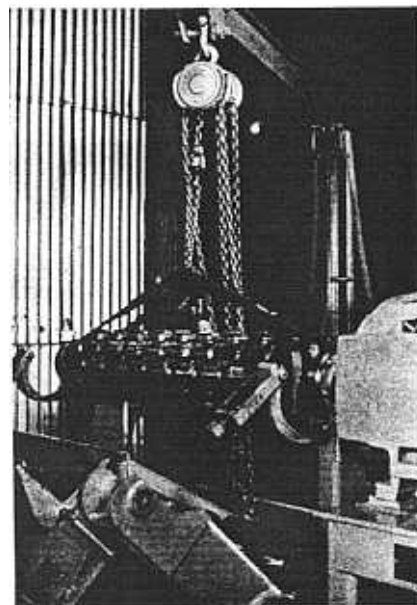


FIGURE 3—Quick-release bearing housing on cutter-head spindle opens to expose bearings and permit fast exchange of the entire cutter-head when knives dull.

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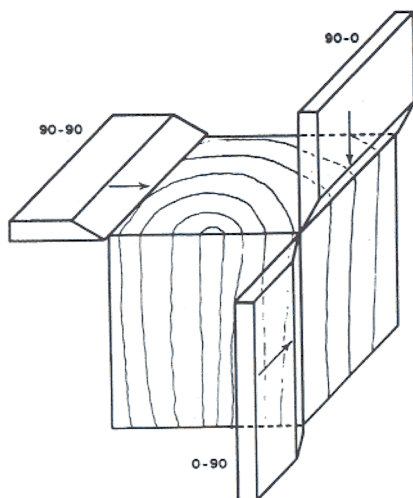


FIGURE 1—Three major machining directions: the first number is the angle the cutting edge makes with the grain; the second is the angle between cutter movement and grain.

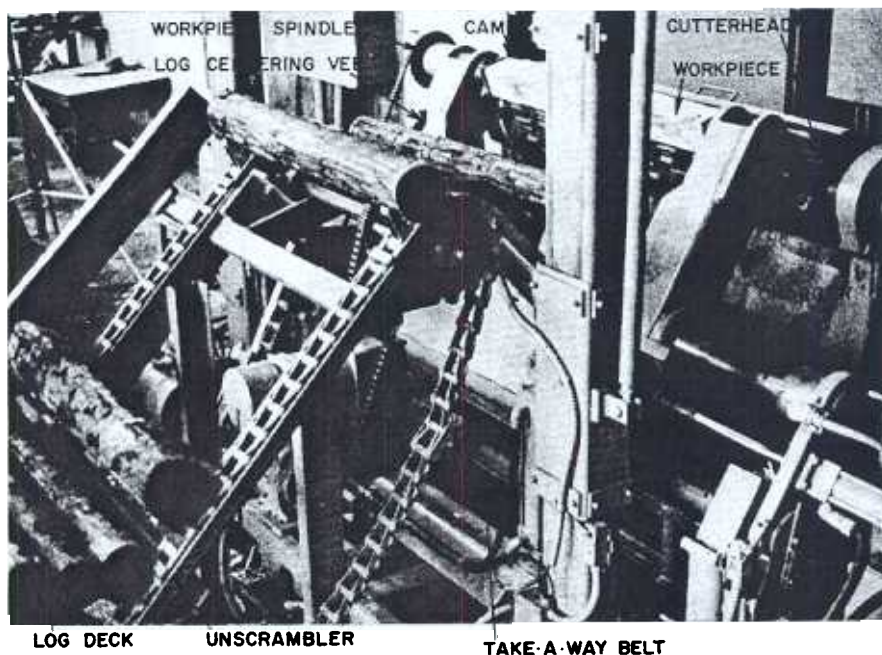


FIGURE 2—Commercial version of the shaping-lathe headrig cuts six logs per minute. Smoothly machined cants have the shape and dimensions of replaceable cams mounted on the workpiece spindle.

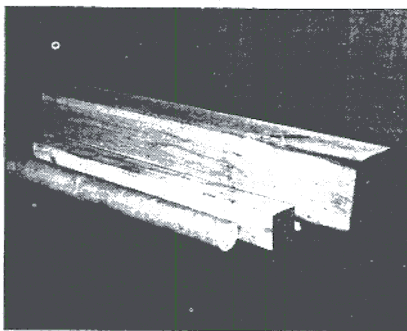


FIGURE 4—Cants produced on the lathe may be rectangular, hexagonal, or trapezoidal as well as square, octagonal, or round. Because knives cut in the veneer direction and take shallow cuts, cant surfaces are smoothly machined with no tear-out around knots.

chining time is brief—approximately four seconds. Feed rate is six bolts per minute.

Cutter Head

The 54-inch-long cutter-head is turned at 3,600 rpm by a 300-hp motor. Its 12 knives are notched with three-inch-long cutting edges to produce a three-inch flake length, and staggered so that only six knives cut any given point on the log (Figure 3). If desired, half the knives can be removed so that only three are cutting. By altering knife holder and knife design, flakes of any length can be cut.

To minimize power requirement and enhance flake quality, rake angle is large—43°. Clearance angle, at 5°, is considered the minimum necessary to avoid undue interference with the work-piece. The resulting sharpness angle of 42° yields a cutting edge moderately resistant to nicking. Knives are 5/16-inch thick, smooth on both sides, and slotted to accept three clamp bolts.

Dull knives must be removed from the head and sharpened on a long-knife grinder. Knives will dull after cutting 1,200 to 1,400 hardwood bolts—a four-hour run. To minimize down-time, the cutter-head is carried in quick-release bearings (Figure 3) that permit fast removal of the entire cutter-head, via monorail hoist, to the grinding room and immediate replacement with another head holding freshly sharpened knives. Down-time for cutter-head replacement is estimated at 25 minutes. Knives can probably wear 1/2-inch before replacement is necessary.

Varying Flake Thickness

Flake thickness is controlled by varying either the work-piece rotational speed or the number of knives

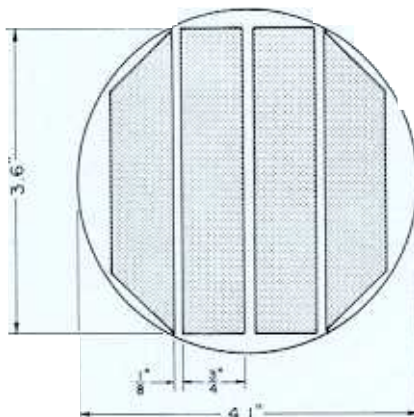


FIGURE 5—When square-edged pallet deck-boards are ripped from the center of octagonal cants and bevel-edged deck-boards are cut from outer portions, lumber recovery on straight logs can exceed 10 board feet per cubic foot of log.

cutting. To accommodate such adjustments, the work-piece is driven from one end with a three-hp, variable-speed motor. The operator's control pedestal carries a digital read-out display of work-piece rpm, permitting him to continuously monitor

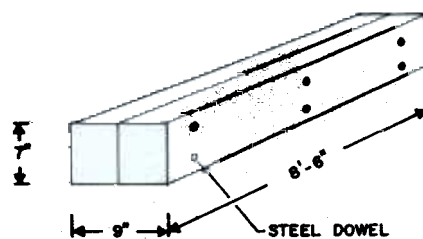


FIGURE 6—Dowel-laminated main-line crosstie secured with three pairs of 1/2-inch spirally fluted steel dowels. No adhesive used.

work-piece speed. He would change work-piece rotational speed to correspond with average diameter (i.e., the diameter midway between bolt diameter and machined diameter). For example, a bolt 12 inches in diameter being machined to an eight-inch square must turn at 10:31 rpm to yield flakes averaging 0.015 inch thick when cut with a six-knife cutterhead. In practice, rotational speeds would likely range from five to 15 rpm. Flake thicknesses of 0.010 to 0.030 would be available by oper-

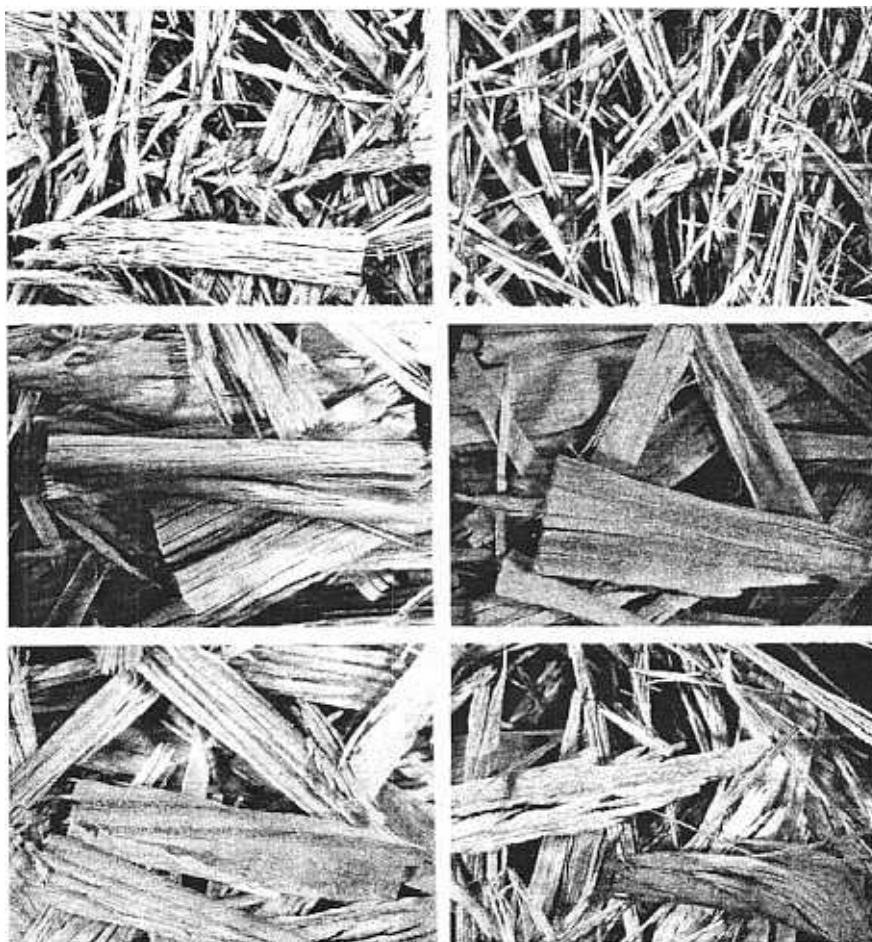


FIGURE 7—Face flakes 0.015 inch thick and three inches long in random widths were produced on the shaping lathe. Top left, white oak; top right, Southern red oak; center left, hickory; center right, sweet gum; bottom left, Southern pine; and bottom right, the five species mixed.



FIGURE 8—Three-layer, five-species flakeboard with randomly oriented flakes throughout (left) or with aligned face and randomly oriented core flakes (right).

ating with six or three knives cutting.

Products

Pallets, cants, posts, and rails.—The headrig should find its primary application in the manufacture of industrial wood parts—principally cants for pallet deck-boards and stringers (Figure 4). Figure 5 illustrates opportunities for high lumber recovery by ripping pallet deck-boards from octagonal cants. Other possibilities for high-yield products include round or octagonal fence rails, highway posts, blocking, and industrial end-grain flooring.

Engineering studies are also under way to design a shaping-lathe capable of producing crossties, posts, and rails in eight-foot-six-inch lengths. Since seven- by nine-inch crossties made from pairs of 4.5- by seven-inch cants joined by steel dowels are feasible for mainline ties (Figure 6), manufacture of such ties from logs 8.4 inches in diameter should provide a major economic opportunity (1).

Structural exterior flakeboard.—The veneer-like flakes produced by the lathe as residue (Figure 7) can be manufactured into a structural exterior flakeboard competitive in function to sheathing grades of plywood. Price competitiveness of the

flakeboard will depend largely on future supplies and costs of resin.

Such a flakeboard would enable utilization of the many low-quality hardwoods growing on Southern pine sites. Using the shaping-lathe headrig, Hse et al. (2) made a ½-inch board from equal-weight portions of hickory, white oak, southern red oak, sweet gum, and Southern pine flakes bound with phenol-formaldehyde (5.5 per cent) and pressed for five minutes at 335°F. All panels had random flake orientation in the core; half the panels had faces comprised of aligned flakes (Figure 8). Properties observed in 18-inch-square panels at 50 per cent relative humidity were:

	Face flake orientation	
	Random	Aligned
Density (lb./cu. ft.)	47.5	45.5
Internal bond strength (psi)	83	82
Modulus of elasticity (psi)	800,000	1,090,000
Modulus of rupture (psi)	5,300	6,625

Several hundred four- by eight-foot panels of these flakeboards are now under intensive evaluation. Results to date are promising.

Medium-density fiberboard.—Flakes cut on the headrig also yield superior disk-refined mechanical fiber for medium-density fiberboard (Figure 9). Fibers of a wide variety of hardwood and softwood species can be mixed with small amounts of

resin to yield hot-pressed boards with near-uniform density throughout panel thickness, good edge integrity and internal bond strength, and reasonably high moduli of rupture and elasticity. Such boards are finding an increasing market in the furniture industry, primarily because their sound edges and smooth faces permit direct printing of surface patterns. The board also finds wide acceptance as a siding material.

Foamed urethane products.—Wood has always suffered in competition with plastics because of its inability to flow under pressure into molded forms. But now, A. A. Marra et al. (4) have developed a process whereby fibrillated wood particles of match-stick size can be carried in a foaming urethane resin to fill curved cavities in a mold. Match-stick flakes produced by up-milling with the shaping-lathe headrig can be molded into intricate forms.

Because molds are inexpensive and the system is tolerant of species and tree grade, the process has substantial commercial potential for manufacture of a wide range of products, including such diverse items as caskets, speaker cabinets,

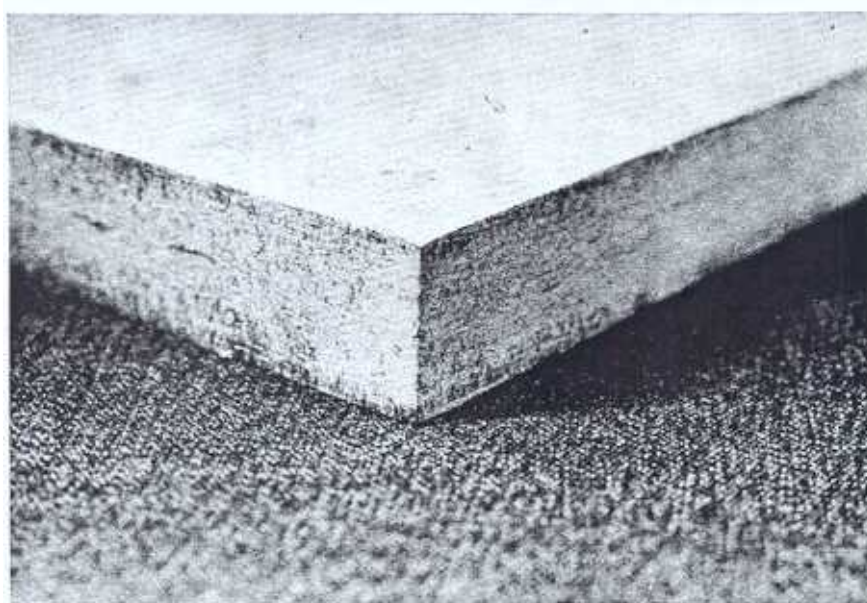


FIGURE 9—Fibers (top) disk-refined from Southern red oak wood are used to make a fiberboard (bottom) that is $\frac{3}{4}$ -inch thick and weighs 42 pounds per cubic foot when at seven per cent moisture content. Modulus of elasticity is 367,000 psi, and modulus of rupture is 3,190 psi.

pallets, containers, and structural panels.

Pulp.—Shaping-lathe flakes can also be pulped in short-dwell-time digestors. Digestors commonly used for a variety of pulps can be regulated to accommodate flakes, but the low bulk density of flakes (about eight or 10 pounds per cubic foot) presents transport problems.

Raw Material Requirements And Yield

A ton of barked round-wood (oven-dry weight) should yield about 0.45 ton of $\frac{3}{8}$ -inch-thick pallet lumber, 0.354 ton of structural exterior flakeboard for sheathing, and 0.22 ton of fuel in the form of bark, sawdust, fines, and panel trim (Figure 10). These tonnages include

board components of 0.02 ton of phenol-formaldehyde resin and 0.004 ton of wax (added to increase board stability during brief changes in rel-

ative humidity). Thus, one ton of barked round-wood will yield 375 square feet of $\frac{1}{2}$ -inch structural flakeboard weighing 45.3 pounds per cubic foot (oven-dry weight) and 242 square feet of $\frac{7}{8}$ -inch-thick lumber (oven-dry weight of 40 pounds per cubic foot of wood is assumed).

Processing this one ton of barked hardwood bolts should require about 3.12 man-hours of labor, supervision and management, 55.6 horsepower hours of mechanical energy, and 1,800 pounds of process steam; during such conversion the manufacturing plant will depreciate about \$6.50 (10-year, straight-line basis).

Productivity And Economics

Minimum plant size that would be economic for the manufacture of $\frac{1}{2}$ -inch flakeboard is debatable. For discussion purposes, an output of 109 tons of board (oven-dry basis) per 24 hours is assumed. It corresponds to 151 four- by eight-foot panels per hour or 6.3 press loads per hour for a six-opening eight- by 16-foot press. This production rate could be satisfied by flakes from two shaping-lathe headrigs operating three shifts per day on mixed hardwoods if bolts average four feet long, seven inches in diameter outside bark, and have an oven-dry weight of 40 pounds per cubic foot, and if each lathe turns out six bolts per minute for 400 minutes in each shift.

In-put would be 15,408 cubic feet, or 308 oven-dry tons, of barked bolt-wood per 24 hours. Output would be 115,000 square feet, or 108.5 oven-dry tons, of $\frac{1}{2}$ -inch flakeboard plus 74,500 square feet of $\frac{7}{8}$ -inch rough lumber for pallets and 67.8 oven-dry tons of fuel. This amount of fuel is more than enough to generate the energy required to run the plant. As is commonly the case in board manufacture, the plant would operate

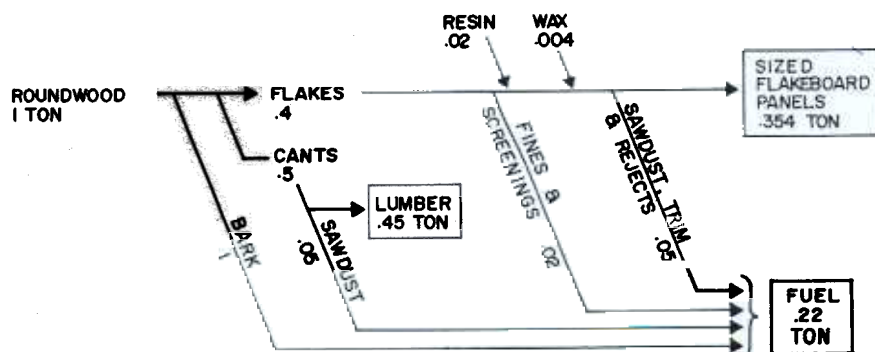


FIGURE 10—Yield from one oven-dry ton of round-wood cut on a shaping-lathe headrig.

seven days a week and 50 weeks a year.

Annual sales of flakeboard for sheathing (at \$120 per thousand square feet, 1/2-inch basis) would be \$4,851,000, and lumber sales would amount to \$3,234,000 (at \$124 per thousand board feet). Annual sales could therefore total \$8,085,000.

Raw material could cost \$2,156,000 a year if cordwood is acquired at \$20 per oven-dry ton. Phenol-formaldehyde resin, at \$0.30 per pound, will cost \$1,293,600 annually. Wax, at \$0.125 per pound, will cost \$107,800. Raw material costs therefore total \$3,557,400 per year.

If it is further assumed that capital investment in site, plant, and depreciable equipment is \$7,000,000, that each shift is manned by 35 laborers, and that supervisory salaries plus all overhead charges (except depreciation) are equal to the labor charge, then the annual statement would be about as follows:

Gross annual sales (after discounts and commissions)	\$8,085,000
Annual expenses:	
Raw material	3,557,000
Labor: 35 men per shift x 3 shifts seven days per week, 50 weeks per year at \$4.50 per hour including fringe benefits	1,323,000
Overhead	1,323,000
Depreciation	700,000
	<u>5,903,000</u>
Profit before taxes	1,182,000

The indicated profit of \$1,182,000 amounts to a return of 16.9 per cent on total plant investment. Although the assumed prices for sheathing and pallet lumber may be difficult to obtain on today's market, they are considered reasonable averages over the next decade.

The round-wood cost of \$20 per oven-dry ton amounts to perhaps \$30 per cord. At this price, it is possible that three-man teams using bob-tailed trucks could be trained to supply the mill with bolts cut accurately to length. With productivity of 10 cords per team per day (15 oven-dry tons per day), only 20 such teams would be needed. As capital equipment for each team is low (about \$5,000), the total investment for harvesting might be only \$100,000.

Ideally, however, stems should be harvested in tree lengths and processed over a log merchandizer at the mill site; this procedure, while more capital-intensive, would permit separation of bolt-wood from more valuable saw and veneer logs.

Conclusions

Application of the shaping-lathe headrig should alleviate shortages of industrial hardwood lumber, since the machine can process small, low-

quality logs. Such hardwoods are abundant throughout much of the eastern United States and are generally found near manufacturing centers and markets. The headrig should also give impetus to two specialty industries—the manufacture of medium-density fiberboard and of wood-resin composites. Further, it is likely to create a third major industry, manufacturing structural exterior flakeboard competitive in price and function with sheathing grades of plywood. Flakes can be produced by the headrig at a fraction of the cost of pine veneer and can be manufactured into structural exterior panels by a less labor-intensive process than that of manufacturing plywood.

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